The Manufacture of Pig Iron

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Everyone is aware of the fact that pig iron occupies a position of great importance in the commercial world and that the blast furnace holds a position of equal importance in the world of science. For these two reasons the manufacture of pig iron challenges investigation.

Pig iron is evidently so called because of the shape the molten metal assumes upon solidification in the molds after having been poured from the furnace. These molds, which may be composed of sand or metal, are really rectangular in shape and have no resemblance to their traditional namesake. But the iron industry is an old one, and while methods have been revolutionized, operation has been wonderfully improved and the output enormously increased, the time honored name of the product still remains even today when a great portion of the iron produced is poured directly into the ladles and converted into steel without remelting.

Pig iron, then, is iron produced in a blast furnace and cast or poured into ladles or molds. In other words, the terms "pig iron" and "cast iron" as used today are practically synonymous.

The modern blast furnace is probably the largest and most complicated piece of metallurgical apparatus in the world. Blast furnace construction has taken enormous strides in the past decade and the modern plant with its six hundred ton daily output has almost entirely succeeded the crude charcoal furnaces of the last century. Indeed, only after seeing one of these old furnaces can one conceive of the vast progress attained in recent years.

A modern blast furnace is primarily a tall circular shaft of varying diameter, from 90 to 100 feet high, built of firebrick re-enforced with a close fitting steel shell and having a cylindrical crucible at its base for the purpose of collecting the molten products reduced in the shaft.

The raw materials are introduced at the top of the shaft and descend to the zone of fusion. Continuing their descent, they reach the crucible where they remain until the accumulation is sufficient to be drawn off.

From the top, the shaft constantly increases in diameter until the fusion zone is reached. The walls then converge until the crucible is reached, where they assume a position perpendicular to the base. The crucible is often called the "hearth" and the part of greatest diameter, the "bosch." Through the lining of the furnace above the hearth extend the tuyeres. Tuyeres are openings through which a hot blast of air enters the furnace to burn the fuel and furnish the necessary heat for the reduction of the ore. The number of tuyeres used depends upon the diameter of the hearth and the size depends upon the capacity of the engine furnishing the blast. These tuyeres are circular in shape and are composed of copper or bronze. The "nose" of the tuyere, which is the part which extends into the furnace, is the part of smallest diameter. The tuyeres as well as the brick work in this vicinity are of necessity water-cooled.

We now have a blast of air at a pressure of, say, from ten to fifteen pounds per sq. in. entering the furnace through the tuyeres. This air must be preheated at some point between the furnace and the blowing equipment to a minimum temperature of 800° F. and often exceeding 1500° F., according to the internal conditions and requirements of the furnace. For this purpose the hot blast stove is used. Each furnace is generally provided with three or more such stoves. They are cylindrical steel shells, generally about the height of the furnace proper, about 22 feet in diameter, and lined with firebrick.

The waste gases from the furnace shaft are carried down to an apparatus which rids them more or less thoroughly of their dust, from which they pass to the gas washer. Subsequent to this process of cleaning and washing, the gases pass to the steam boilers, blowing engines and the stoves.

The gas is admitted to the stove and ignited at a point slightly above the base. It passes upward through the chamber of brickwork, which readily absorbs the heat. The gas is then shut off and the air from the blowing engines is passed through the chamber, absorbing the heat from the preheated brickwork. One stove is allowed to heat the blast while the others are being heated from the waste gases. After a stove has heated the blast for an hour, another is put on blast, and the former one put on gas. By regularly changing the stoves, from gas to air and from air to gas, a constant temperature may be maintained.

The raw materials are stored in bins and are carried to the top of the furnace by means of an inclined plane. After reaching the top they are automatically discharged upon the "'bell." This is so called from its shape. It fits snugly into an inverted truncated hollow cone which forms the top of the stack. This forms a hollow crater with the bell for a bottom. The bell also acts as a gas seal when the stock is being filled into it. When the correct weight of materials is placed on the bell, it is automatically lowered and the charge slides into the furnace.

These changes consist of constant weights of iron ore, coke, and limestone. Each member of the charge is previously analyzed and from the chemical composition the correct weight is determined. This calculation is called burdening the furnace.

The chemical action within the furnace is essentially a reducing action. Iron ore is an oxide of iron, together with more or less impurities. Coke is composed mostly of fixed carbon. It contains approximately ten per cent ash and the remainder is volatile matter. Limestone is a carbonate of lime with impurities.

The gaseous carbon from the coke reduces the iron oxide to metallic iron and the limestone converts the majority of the impurities in the charge into a fusible slag or cinder, which is drawn off at a point below the tuyeres. Owing to the difference of their respective specific gravities, the metal is separated from the slag and sinks down to the bottom of the hearth where it is drawn off as molten iron.

The following example is cited to show the composition of the raw materials:

Iron Ore		Silica	5.30 %
Iron	53.49 %	Alumina	3.00 %
Phosphorus	.040%	Lime	1.00 %
Manganese	.300%	Magnesia	.70 %
Silica	6.34 %	Phosphorus	.020%
Alumina	2.70 %	Sulphur	.75 %
Lime	.380%	*Limestone*	
Magnesia	.240%	Silica	1.42 %
Sulphur	.009%	Alumina	2.12 %
Coke		Lime	46.22 %
Fixed Carbon	86.50 %	Magnesia	6.44 %
Volatile Matter	2.73 %	Phosphorus	.005%

The iron produced from the above materials will contain the elements: silicon, sulphur, phosphorus, manganese and carbon. Part of the silica in the charge will be reduced to silicon and enter the iron and the remainder will be found in the slag. A portion of the sulphur in the charge will volatilize and join the ascending current of gases and the remainder will either enter the iron or the slag. Practically all of the phosphorus in the charge will be found in the iron. Theoretically one-third of the manganese in the charge will enter the slag and the remaining two-thirds will enter the iron. Only a part of the carbon contained in the fuel will be found in the iron.

The slag will contain all of the elements found in the limestone, with the possible exception of phosphorus. It will also contain most of the sulphur of the charge.

Such in brief is an attempted synopsis of the manufacture of pig iron. It is indeed regrettable that the industry is so segregated in this country and that metallurgical literature is of such a technical nature as to discourage any but the technical men. But it is hoped that the reader can at least gather from this outline an idea of how iron is manufactured and also what a complicated piece of apparatus a modern blast furnace is. It can be seen that the process of smelting in a blast furnace is essentially a continuous one. The furnace must be in operation 24 hours per day and 365 days per year. Sometimes a furnace is operated for many years with only temporary cessations of only a few hours.

By seeking to avoid technical terms and phrases, it has been impossible to picture either the action or operation of the furnace except from a very elementary standpoint, but it is hoped that this will serve to stimulate a further interest in ferrous metallurgy.